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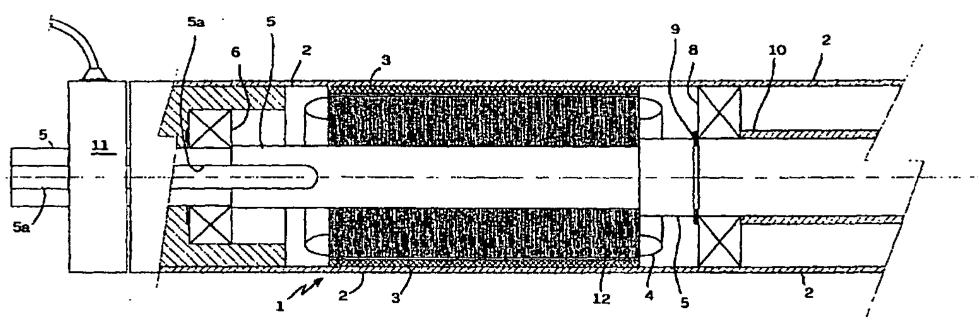

(57) Abstract: A motor roller (1) for transferring articles or materials comprising a hollow cylindrical drum (2) of a material of high magnetic permeability, rotably supported on a structure and a driving motor housed inside the drum (2), has a substantially cylindrical tubular sintered body (3) of a material permanently magnetized per longitudinal stripes defining a plurality of magnetic poles of alternate sign uniformly arranged around the circumference of the tubular body (3) installed inside the drum (2) of material of high magnetic permeability and mechanically connected to it with minimum gap between the outer surface of said permanently magnetized tubular body (3) and the inner surface of the drum (2). The cylindrical surface of the drum (2) has thickness sufficient to provide for the closing of the plurality of magnetic flux circuits between poles of opposites sign defined one adjacent to the other in the tubular body (3) permanently magnetized per longitudinal stripes without reaching saturation conditions. An axle-stator (4) is held on an axle (5) and is fixed to said supporting structure and by means of at least a bearing mounted on said axle rotably sustains the hollow drum. A driving system of phase windings of said axle-stator (4) in synchronism with the angular position of the outer rotor constituted by said drum (2) and by the stripwise permanently magnethized tubular body (3) actuates the closed loop regulation of the rotating speed of the motor in a certain motion direction of rotation.

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"MOTOR ROLLER"

The present invention relates to conveyor devices and systems for transferring articles or materials and in particular to a motor roller that may be used in such systems and devices.

The unrelented automation of processes in industry trade, and in the supply of services implies an ever increasing use of conveyor devices and systems for transferring articles and materials, such as motor rollers, belt conveyors and the like.

The main requisites of these systems are those of sustaining the articles or materials that are being transferred and of advancing them, often in a precisely controlled manner.

Ever more frequently conveyors must accomplish the double function of "acceleration servomechanism" and of "position servomechanism".

Motor rollers are fundamental parts of most of these devices and systems.

For examples, belt conveyor "handling machines" are machines generally employed for transferring packed materials to specific destinations that are assigned to the single packets by affixing a bar code thereon. Very often the extension of such machines are comparable to that of the building in which they are installed, therefore the number of parts and components to be used for constructing them, their weight and their encumbrance are determinant factors ad well as their costs.

Basically, minimum encumbrance, lightness, straightforward mechanical design (which is a factor of reliability) are generally required together with the possibility of controlling the motion of the motor rollers not coarsely but in a substantially deterministic fashion, which often becomesthe most important requisite.

Merit figures of motors employed for driving the rollers relate basically to mechanic and electric time constants, pass band (ever increasing critical operating

frequencies), inertia (affecting the speed of response) and last but not least efficiency that determines valuable energy saving. Moreover, large pulsed torque values allow to perform a great number of destinations per hour.

The most commonly used configurations employ synchronous, inductive or stepper DC motors equipped with mechanical transmissions for coupling the motor shaft to the roller that imply a redundance of mechanical devices. The use of toothed belts and of relative pulleys force the designer to provide for robust supporting structures of relatively large size and weigh, as well as crankcases for safety reasons and for preventing accidental interferences of objects of any kind with the mechanical transmissions.

In order to reduce encumbrance and to simplify maintenance and repairing operations, motor rollers with relative driving motor and epicyclical speed reduction gear conveniently installed inside the roller itself substantially made of a hollow cylinder or drum of adequate rigidity, have been proposed.

Most often, the driving motor is either a DC motor or a synchronous motor coupled to an epicyclical speed reduction gear box whose output shaft is connected to the drum by a disk keyed to the output shaft of the reduction gear and fastened to the inner surface of the cylindrical drum by stud screws, bolts, or other suitable fasteners.

The motor-reduction gear assembly is fixed on the supporting structure of the roller. Commonly the assembly is fastened to shoulders or lateral plates of the structure destined to rotably support the rollers. A bearing of the drum may be installed on the supporting arm of the motor-reduction gear assembly and connected to the drum for preventing any undesired slanting of the drum in respect to the axis of rotation of the output shaft of the motor-reduction gear in order to reduce assembly vibrations and make the motor roller mechanically more stable.

Notwithstanding these arrangements, the level of noise that is normally generated

by speed reduction gear boxes is relatively high and, as in the case of more traditional arrangements employing a belt transmission, control and regulation of the speed of the motorized roller often imply the use of sensors installed around the roller on which small magnets may commonly be installed, for cooperating with externally positioned Hall effect sensors, from the output signals of which it is possible to decode both the direction of rotation and the speed of rotation of the roller.

Typically, the electronic control and regulation systems function in a closed loop current mode.

Though reducing encumbrance, installation of the driving motor and of the speed reduction gear inside the roller does not reduce weight, and on the other hand it increases vibrations and noise caused by the use of speed reducing gears instead of belt transmissions.

Moreover, deployment of magnets for discriminating rotation direction and speed is in contrast with the requisite, which is often important, of ensuring an absolute absence of magnetic lines of force that may affect products and materials to be handled particularly sensible to magnetic flux.

By resuming, among aspects and requirements for which there is a clear need of improvement are the following:

- reduction of fabrication costs;
- reduction of weight and of the number of parts;
- efficiency and safety;
- direct control of the motion;
- quietness of operation;
- performance;
- shielding of magnetic flux.

Vis-a-vis these needs, it has now been found and is the object of the present

invention a motor roller that does not require any speed reduction gear nor any mechanical transmission, that may be controlled and regulated directly and with improved precision, and which provides for a reduction of costs, a reduction of the total weight, a reduction of noise and of vibrations and other ancillary advantages, as they will be highlighted hereinbelow.

An essential feature of the invention is the fact that the cylindrical drum or at least a portion of it is a functional part of a permanent-magnet motor.

According to a first embodiment of the invention, at least a cylindrical portion of the hollow drum that constitutes the roller is made of a material having a high magnetic permeability and a thickness sufficient to provide paths for the magnetic flux to close the magnetic circuit between poles of opposite sign defined, one adjacent to the other, in a tubular body that is permanently magnetized per longitudinal stripes and that fits inside and is fastened to the cylindrical portion of the drum of the material of a material of high magnetic permeability.

The drum and the permanently magnetized cylindrical body defining a plurality of magnetic poles of alternated sign along the circumference, constitute together an "outer rotor" cooperating with an inner stationary axle-stator, coaxially fitting inside the tubular body permanently magnetized per longitudinal stripes.

The so constituted "outer rotor" is rotably supported by at least a bearing installed on the stationary axle of the axle-stator that is mechanically fixed to an external support structure.

The whole hollow cylindrical drum may be of steel of high magnetic permeability or may even be such a material only for a portion of its total length (e.g. corresponding to the width of the conveyor) for allowing the use of a lighter nonmagnetic material, for a example reinforced resin, for constituting the remaining portion of the drum when weight reduction is of primary importance and/or particularly long rollers are needed.

While ensuring an absolute absence of magnetic lines of force outside the roller, as may be required for transferring products adversely affected by magnetic fields, the thickness of the cylindrical wall of the drum of a material of high magnetic permeability may be as small as 1.5 mm, as it will be illustrated in greater detail in the ensuing description.

According to an alternative embodiment, the medium for closing the paths of magnetic fluxes and for providing an effective shield ensuring absence of any stray line of force outside the roller, may be in the form of a sleeve of steel of high magnetic permeability fitted on the outer cylindrical surface of the permanently magnetized tubular body. Such a subassembly may be installed inside the drum and fixed to it by means of a structural adhesive and/or by screws, bolts and the like.

The tubular body of permanently magnetizable material may be of any known material commonly used for permanent magnets. For example, a sintered cylinder of magnetic material containing neodymium may be used. Cylinders of so-called plasto-neodymium produced and marketed by the Chinese KONIT INT. CO. may be used satisfactorily.

Of course, the length of the tubular body of a permanently magnetized material per longitudinal stripes is a determining parameter of the motor design. Should such a parameter, or more precisely the ratio diameter/length, be excessively small and such to make difficult the fabrication of relatively long sintered tubular bodies, it is possible to realize the tubular body as a composite, instead of in single piece, simply by stacking together cylindrical "modules" having a ratio diameter/length appropriately large for the fabrication technology of such sintered articles as needed to reach a desired total length of the composite tubular body .

The distinct segments or modules are abutted end to end before magnetizing the composite tubular body per longitudinal stripes, thus avoiding the problem of forcibly abutting magnetic poles of the same polarity.

The distinct tubular segments may be held together by bonding with a structural

adhesive of appropriate characteristics, eventually using also a heat-shrinkable plastic sheath and/or be connected one to the other by means of brackets, screws and the like. Optionally the abutting end surfaces of the cylindrical segments stacked together may be provided with indentations and protrusions cooperating with each other to register the relative positions of the two pieces and prevent any mutual rotation of a piece about the other, especially in the case in which only a sheath of heat-shrinking material is used for holding the tubular modules together.

The so assembled composite cylindrical body is then magnetized per longitudinal stripes, according to the known techniques normally used for this purpose.

The invention is more clearly defined in the annexed claims. The different aspects and advantages of the invention may be explained more easily through a detailed description of several possible embodiments and by referring to the attached drawings.

Figure 1 is a simplified partial sectional view of a motor roller of the present invention;

Figure 2 is a sectional view illustrating a preferred embodiment of the outer rotor of the motor roller of the invention;

Figure 3 depicts a modular embodiment of the permanently magnetized cylindrical body of the motor roller of the invention;

Figure 4 depicts the profile of the die stamped ferromagnetic laminae of the axle-stator of the motor roller according to an embodiment of the invention as exemplified in previous figures;

Figures 5 and 6 show a possible embodiment of permanently magnetized concentric rings for realizing a position and speed transducer;

Figures 7 and 8 show the disk on which are adjustably fixed magnetic sensors cooperating with the concentric rings of Fig. 5 for implementing the transducer.

Referring to Fig. 1, the peculiarity of the motor roller of the invention is the fact that advantageously it does not include any speed reducing and mechanical transmission device.

In the embodiment shown solely for illustrative purposes as an aid for describing the invention in the clearest manner, the motor roller 1 comprises a drum 2 that may be for example a hollow cylinder of mild steel of high magnetic permeability and with a wall thickness of no less than 1.5 mm and a length suited to need.

A tubular body 3 permanently magnetized per longitudinal stripes in order to define, in the considered example, twentyfour magnetic poles of alternated polarity uniformly distributed around the circumference of the tubular body 3, is installed inside the drum 2, or at least inside said of it composed of a material of high magnetic permeability, and fixed to the drum 2.

The tubular body may be a sintered cylinder of plasto-neodymium produced by the Chinese KONIT INT. CO. In the considered example the dimensions of the tubular body 3 are: length 57 mm, outside diameter 48 mm, inside diameter 43 mm.

Assembling of the permanently magnetized tubular body 3 inside the ferromagnetic drum 2 of the motor roller is done with relatively small dimensional tolerances thus minimizing the gap between the two tubular bodies to the point of making it negligible. To this end, the inside diameter of the ferromagnetic portion of the drum 2 is equal to the outside diameter of the permanently magnetized tubular body 3 plus a minimum tolerance just for allowing the insertion of the tubular body 3 inside the drum 2.

Finally the two tubular bodies are mechanically connected to constitute a cylindrical composite rotor. Connection of the tubular body 3 to the outer drum 2 may be realized using a structural adhesive of suitable characteristics, according to common techniques of fabrication of permanent-magnet motors.

Fig. 2 depicts a sectional view of the outer cylindrical rotor of the motor roller of the invention defining, in the considered case, twenty four magnetic poles.

The poles are defined by magnetizing the tubular body 3 by twentyfour

longitudinal stripes of equal angular extension along the circumference of the cylindrical body.

A axle-stator 4, whose axle 5 has a longitudinal channel 5a in which supply wires of the phase windings of the motor (not depicted in the mentioned figure) are arranged, is fixed to a supporting structure (not depicted in the mentioned figure) and the drum 2 is rotably sustained in a perfectly coaxial position in respect to the axle-stator 4 by a first bearing 6, which in the illustrated example is installed inside a "cup" terminal 7 of the drum 2, for example of a resin or of a light alloy.

Preferably, in the case of rollers of considerable length, it is recommendable to use a second anti-flection bearing 8 installed on the same axle 5 of the axle-stator 4 on the other side of the stator, in order to prevent flections of the rotating drum 2 about the axis of the axle-stator 4.

This second anti-flexion bearing 8 is kept in position by a common Seeger ring 9 and by a bearing-stopper sleeve 10 or by any other mechanical stopper.

Clearly the drum 2 and the permanently magnetized tubular body 3 connected to it rotate around the axle-stator 4 that is mechanically connected to the supporting structure of the motor roller.

Fig. 4 shows the profile of the die stamped laminae 12 that are customarily stacked together to compose the ferromagnetic pack of the axle-stator 4. In the depicted embodiment, the ferromagnetic pack of the axle-stator 4 defines eighteen channels in which three phase windings are arranged. The axle-stator 4 includes six coils of 1:2 pitch connected in series for each of the three phases, the number of turns of which is established in function of the supply voltage and of the required maximum speed.

The motor roller of the invention may be driven in a precisely controlled way even using control and driving electronic systems suitable to implement sensorless control and synchronization algorithms of the phase switchings that do not require

any sensor of the angular position of the outer rotor, that is of the drum 2.

More traditionally, controlling and driving in perfect synchronism the motor roller of the invention may be based on the use of specific speed and position sensors.

Such an embodiment is depicted in Fig. 1, wherein the such assembly of the speed and position transducers is indicated as a whole by 11.

According to a preferred embodiment as depicted in Figs. 5 and 6, the transducers are composed of a pair of concentric rings 13 and 14 of a material permanently magnetized per sectors mechanically connectable to an extremity of the drum 2 in order to rotate with it.

A first ring 13, for example of ferrite or of plasto-neodymium, is magnetized per sectors of identical and minimum angular size, thus defining for example 120 magnetic poles of alternated sign along the circumference.

A second ring 14, also constituted of ferrite or of plasto-neodymium, is magnetized per sectors of identical angular size defining the same number (24) of magnetic poles of the motor roller.

As schematically depicted in Figs. 6 and 7, a disk 15, for example of glass-fiber reinforced plastic PCB, has sensors mounted thereon and has copper connection pads P patterned thereon. The disk is mounted on the supporting axle 5 of the axle-stator 4 of the motor roller with the sensors facing toward the rotating rings 13 and 14 of permanently magnetized material.

At least three sensors A, B and C generate discrimination signals of the angular position of the drum (outer rotor) and at least a cell D end codes the speed of rotation.

Referring to the sectional view of Fig. 7, the relative angular position of the disk 15 carrying the sensors on the hub 16 fixed on the supporting axle 5 of the axle-stator 4 may be adjusted when trimming the control and driving system of the

motor roller.

Of course, as it will be evident to the skilled artisan, the transducers for detecting the angular position and the speed of the motor roller and the relative encoding and decoding systems of the signals coming from sensors may be of different types and be chosen among many known devices used for these purposes.

For example, in case the required performances set out in the specifications of the motor roller would impose an excessively large number of magnetic poles to be defined in rings of permanently magnetizable material, as in the example depicted in Fig. 5, the technological problem of fabrication may be overcome by using rings realized with comb-like die stamped laminae of a ferromagnetic sheet material, whose teeth define as many magnetic poles.

Alternatively, the transducers may be of optical kind employing photodiodes and phototransistors and rings of an opaque material provided with radially extending slits, according to well known techniques.

The thickness of the whole drum 2, or of the portion of high magnetic permeability, is sufficient to provide paths for the magnetic flux closing the plurality of magnetic circuits between adjacent poles defined in the tubular body 3 of material permanently magnetized per longitudinal stripes without reaching a saturation condition of the ferromagnetic material of the drum 2.

It has been found that for chords of relatively small dimensions of the single poles relatively small dimensions, as defined by magnetizing by stripes to form twentyfour poles around the circumference of the tubular body 3, as in the shown embodiment a drum 2 of steel of high magnetic permeability with a thickness of 1.5 mm is perfectly adequate to prevent the presence of any stray magnetic line of force in the vicinity of the outer surface of the drum.

In other words, the drum 2, or the segment made of a material with high magnetic permeability constituting together the tubular body 3 permanently magnetized per

stripes the outer rotor of the motor roller of the invention, perfectly contains all magnetic fluxes and ensures an absolute absence of magnetic interferences with the transported articles or materials.

In case magnetic sensors are used for generating speed and angular position signals, the relative sub-assembly 11 may be easily shielded to prevent stray lines of force outside the shielding case.

Of course it is also possible to associate to the tubular body 3 of a material permanently magnetized per longitudinal stripes an outer sleeve of a material of high magnetic permeability of adequate thickness to accomplish the closing of the multiple magnetic circuits between adjacent poles without saturating and to install the so pre-assembled parts inside a drum 2 that may also be of steel thus enhancing the magnetic shielding or in this case even be of an amagnetic material, provided that the sleeve of high magnetic permeability satisfies the requirement of confining all the lines of force of magnetic fluxes.

The motor roller of the invention offers many advantages.

Fabrication costs are lower because of the reduction of the total number of parts and of their relative simplicity.

The total weigh of the motor roller of the invention is sensibly reduced in respect to a motor roller of the prior art of comparable characteristics.

The motor roller may be designed with a much greater freedom than prior art rollers to achieve the maximum reduction of encumbrance.

The relatively simple construction and the reduced number of components enhance reliability and safety.

Direct control of the motor roller improves its dynamic performance.

The absence of mechanical transmissions makes the motor roller of the invention outstandingly noiseless.

CLAIMS

1. A motor roller for transferring articles or materials comprising a hollow drum substantially cylindrical at least for a portion of it, rotably supported on a structure and a driving motor housed inside said hollow drum, characterized in that

at least said cylindrical portion of hollow drum is of a material of high magnetic permeability;

a substantially cylindrical tubular sintered body of a material permanently magnetized per longitudinal stripes defining a plurality of magnetic poles of alternate sign uniformly arranged around the circumference of the tubular body, is installed inside said drum in correspondence of said cylindrical portion of material of high magnetic permeability and mechanically connected to it with minimum gap between the outer surface of said permanently magnetized tubular body and the inner surface of said cylindrical portion of material of high magnetic permeability of the drum having a thickness sufficient to provide for the closing of the plurality of magnetic flux circuits between poles of opposite sign defined one adjacent to the other in said tubular body permanently magnetized per longitudinal stripes without reaching saturation conditions;

a axle-stator is held on an axle that is fixed to said supporting structure and at least a bearing mounted on said axle, rotably sustains said hollow drum;

driving means of phase windings of said axle-stator in synchronism with the angular position of the outer rotor constituted by said drum and by said stripwise permanently magnetized tubular body are commanded by a regulation system of the rotating speed of the motor in a certain motion direction of rotation functioning in a closed loop mode.

2. The motor roller according to claim 1, characterized in that said substantially cylindrical tubular body permanently magnetized per longitudinal

stripes is a sintered permanent magnet material containing neodymium.

3. The motor roller according to claim 1, characterized in that in said tubular body permanently magnetized per longitudinal stripes are defined twentyfour magnetic poles of identical angular extension distributed around the circumference and said axle-stator has a ferromagnetic pack defining eighteen longitudinal channels in which six windings in series for each of three driving phases are arranged.

4. The motor roller according to any of the preceding claims, characterized in that said tubular body permanently magnetized per longitudinal stripes is composed of modular cylindrical bodies of same circumference and wall thickness coaxially stacked and fastened together for constituting a tubular body of a desired length, before magnetizing per longitudinal stripes the so composed tubular body.

5. The motor roller according to claim 4, characterized in that the stacked cylindrical bodies are held together by a sheat of a heat-shrinking plastic material.

6. The motor roller according to claim 4, characterized in that the stacked cylindrical bodies are held together by bonding with a structural adhesive.

7. The motor roller according to claim 4, characterized in that the stacked cylindrical bodies are held together by mechanical fasteners.

8. The motor roller according to any of the preceding claims, characterized in that said cylindrical portion of material of high magnetic permeability of said hollow drum is of mild steel and has a wall thickness of at least 1.5 mm.

9. The motor roller according to any of the preceding claims, comprising magnetic sensors of the angular position and rotation speed of the outer motor.

10. The motor roller according to claim 9, characterized in that said sensors

comprise two rings of a material permanently magnetized per sectors defining a plurality of adjacent magnetic poles of alternate sign around the respective circumference mechanically connected to said drum, and a fixed disk carrying magnetic transducers, at desired angular positions adjustably held on a hub ring installed on the fixed axle of said stator.

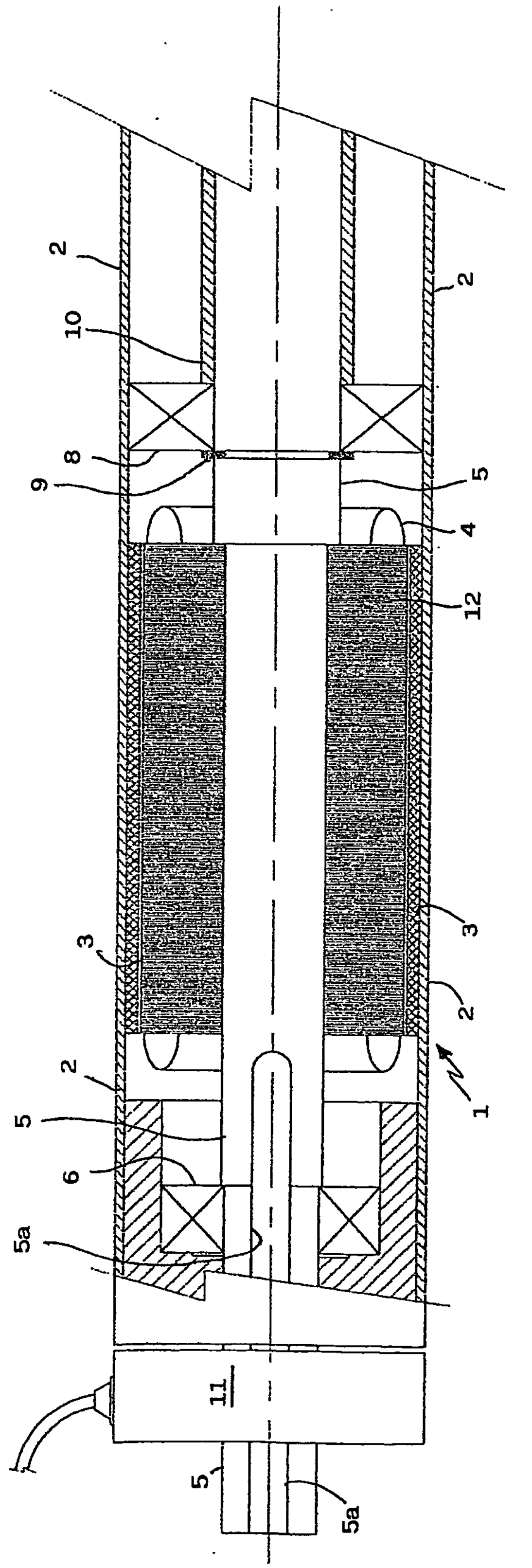

FIG. 1

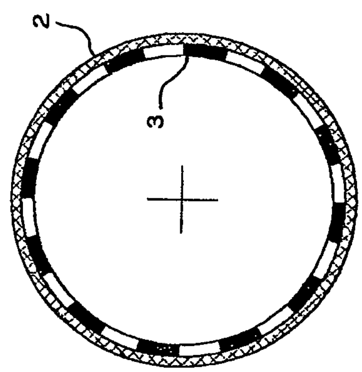

FIG. 2

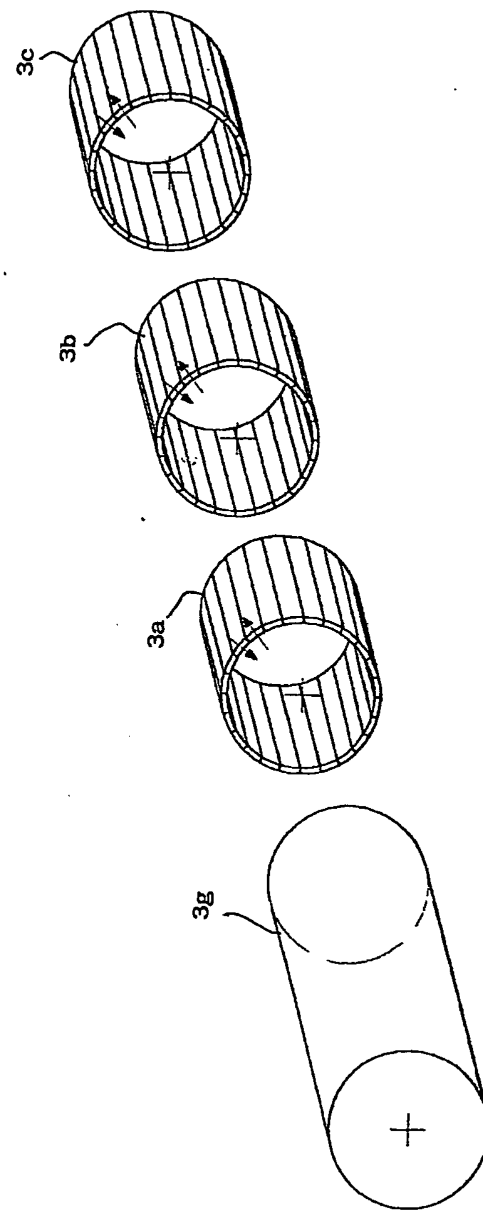

FIG. 3

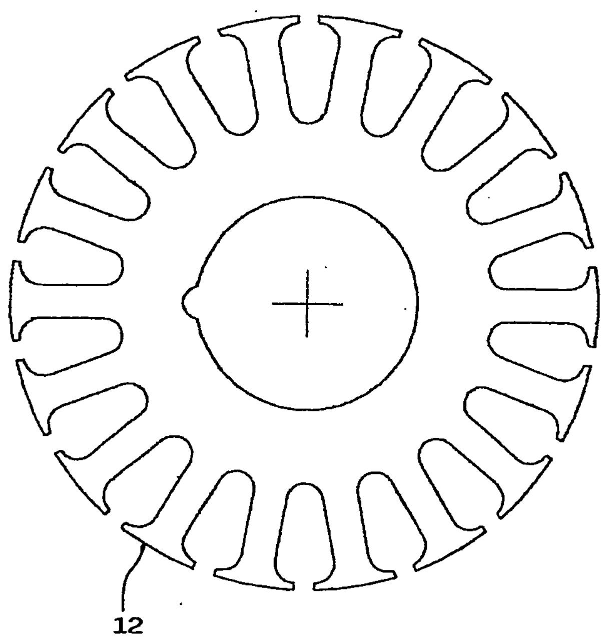

FIG. 4

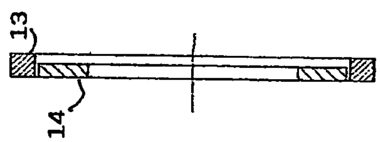

FIG. 6

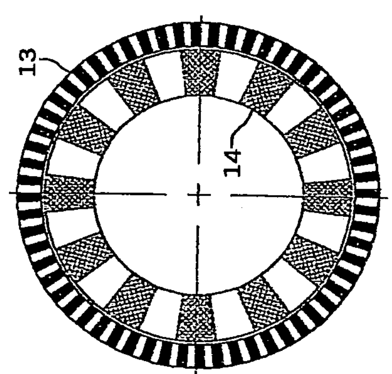

FIG. 5

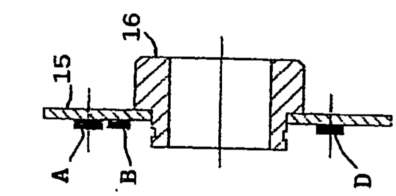

FIG. 8

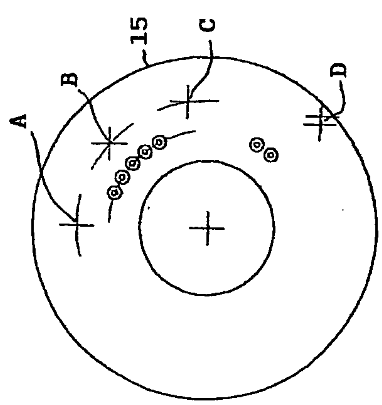

FIG. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT 01/00321

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B65G23/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B65G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 244 427 B1 (SYVERSON CHARLES D) 12 June 2001 (2001-06-12) column 3, line 29 -column 8, line 11 figures 1-8	1-10
A	US 5 923 111 A (ENO JAMES JOSEPH ET AL) 13 July 1999 (1999-07-13) column 3, line 41 -column 5, line 64 figures 1-11	1-10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
19 March 2002	28/03/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Papatheofrastou, M

INTERNATIONAL SEARCH REPORT

Interna[redacted]al Application No
PCT/IT 01/00321

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6244427	B1	12-06-2001	US	6206181	B1	27-03-2001
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US 5923111	A	13-07-1999	AU	1372599	A	31-05-1999
			WO	9925055	A1	20-05-1999